# *NCODA Status*
# *NRL Coupled Ocean Data Assimilation*

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***HYCOM NOPP GODAE Meeting***

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***Outline***

1. ***NCODA System Overview***
2. ***New Analysis Capabilities***

# Report Documentation Page

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# NCODA System Overview

**Flexible System**

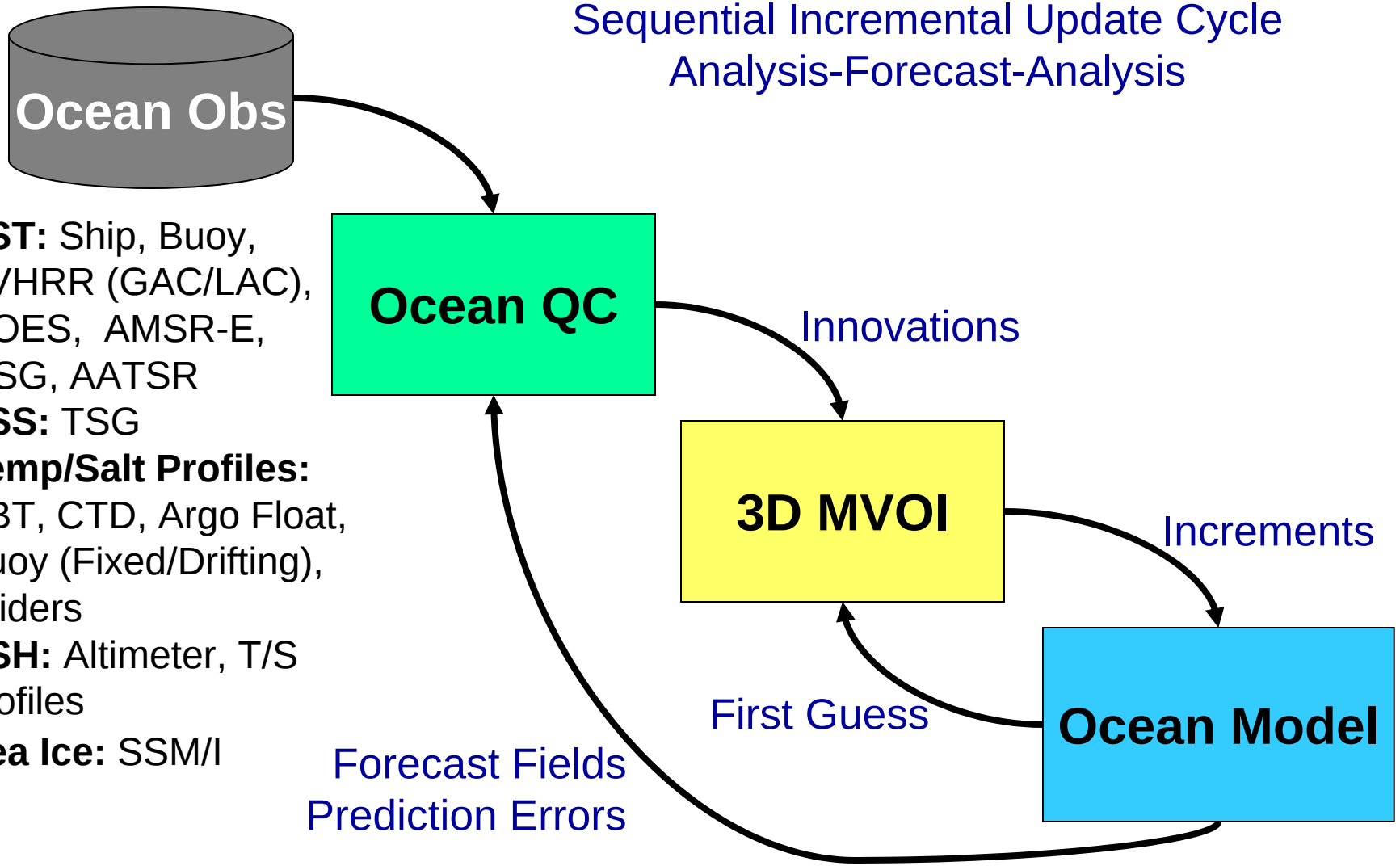
- global or regional applications
- re-locatable, multi-scale analyses on nested, successively higher resolution grids (3:1 nest ratios)
- update ocean forecast model or run stand-alone
  - 2D analyses of sea ice and SST (NWP boundary conditions)
  - 3D temperature and salinity analysis (geostrophic currents)
  - 3D MVOI sequential incremental update cycle (model-based)

**Designed as Complete End-to-End Analysis System**

- data quality control, analysis, performance diagnostics
- operational at Navy Centers in analysis-only mode
  - Naval Oceanographic Office
  - Fleet Numerical Meteorology and Oceanography Center

# NCODA Implementation

Sequential Incremental Update Cycle
Analysis-Forecast-Analysis



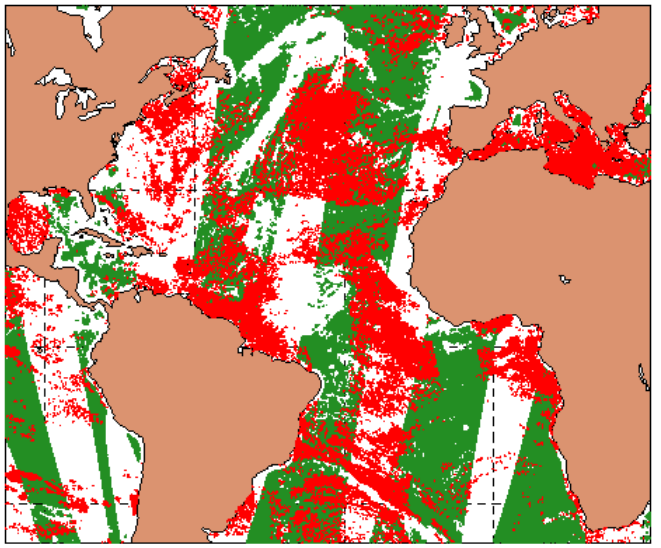

**SST:** Ship, Buoy, AVHRR (GAC/LAC), GOES, AMSR-E, MSG, AATSR
**SSS:** TSG
**Temp/Salt Profiles:** XBT, CTD, Argo Float, Buoy (Fixed/Drifting), Gliders
**SSH:** Altimeter, T/S profiles
**Sea Ice:** SSM/I

Model forecast fields and prediction errors are used in the QC of newly received ocean observations

# New NCODA Capabilities

## Analysis

- first guess appropriate time (FGAT)
- flow dependent correlations
- analysis error
- model climate error variance fields
- age of data on grid analysis variable
- pressure correction analysis variable
- data restriction in boundary areas



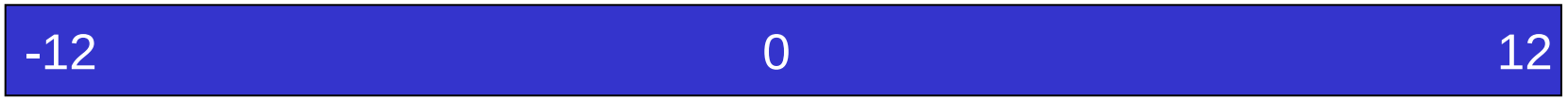
AVHRR-GAC AMSR-E

12-hrs data

## Observing Systems

- MeteoSat SST (MSG) from MeteoFrance (CMS-Lannion)
- Microwave SST (AMSR-E) from Remote Sensing Systems
- Ocean Gliders (up/down profiles, position varies with depth)

# Sequential Incremental Update Cycle




***Data Window (+/- 12 hours)***

**24 Hour Forecast**

**Innovations**

*Length update cycle user defined*
*All observations considered synoptic regardless length update cycle*

# First Guess at Appropriate Time


***Data Window (+/- 12 hours)***

**12 Hour Forecast** | **18 Hour Forecast** | **24 Hour Forecast** | **30 Hour Forecast** | **36 Hour Forecast**

**Innovations**

*Length update cycle user defined*
*Interval of forecast periods user defined*
*Eliminates component of mean analysis error that occurs when comparing observations and forecasts not valid at same time*

# Flow Dependent Correlations

***$h_s$ = 0.2***

small (large) $h_s$ produces strong (weak) flow dependence

$$s_h = (x_o - x_b)/x_s \qquad C_h = (1+s_h)\exp(-s_h)$$

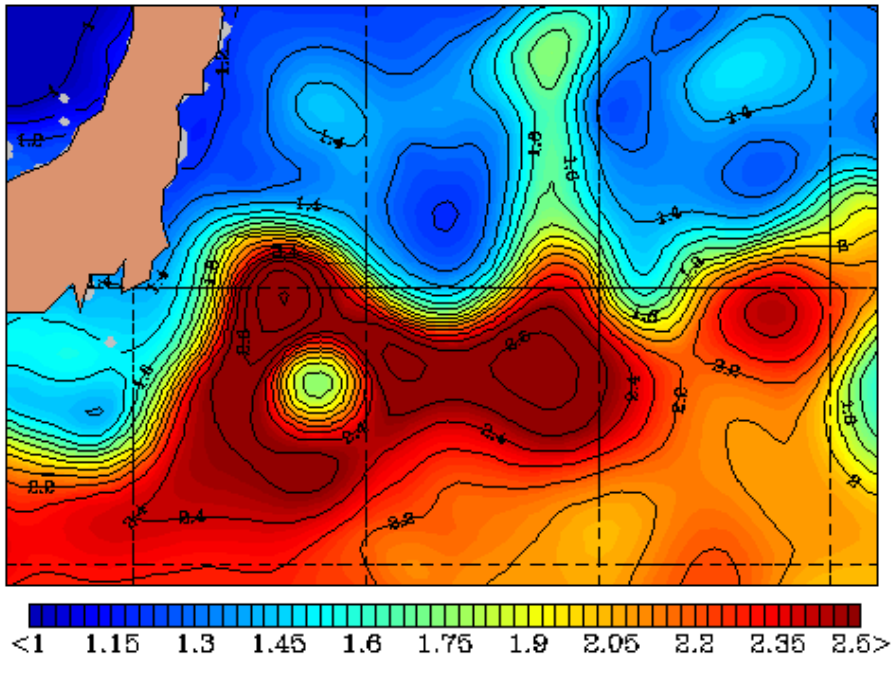
$$s_v = (z_o - z_b)/z_s \qquad C_v = (1+s_v)\exp(-s_v)$$

$$s_f = (h_o - h_b)/h_s \qquad C_f = (1+s_f)\exp(-s_f)$$

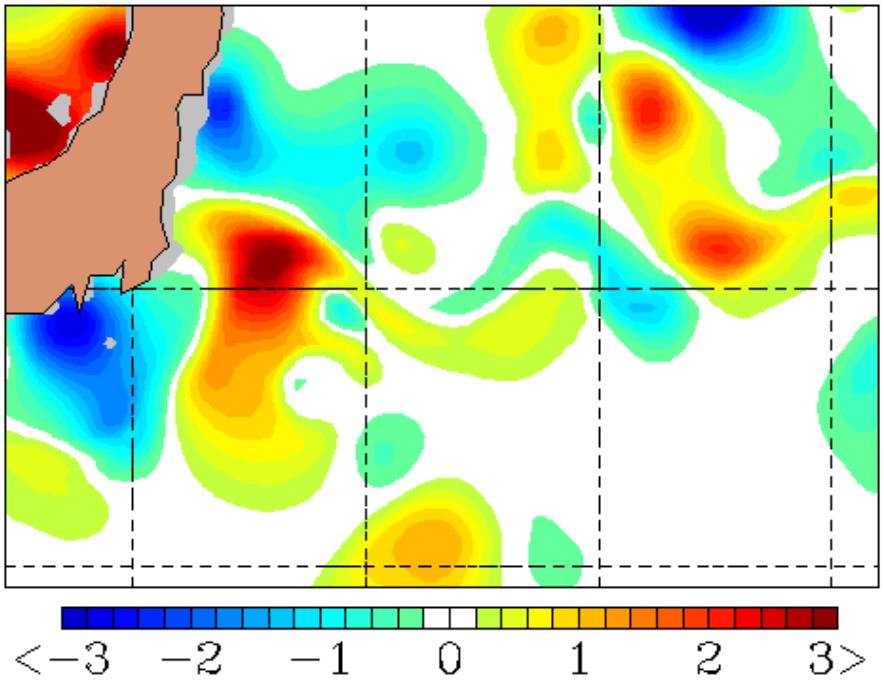
$$C_b = C_h C_v C_f$$

$x_s$ = horizontal scale (km)
$z_s$ = vertical scale (m)
$h_s$ = flow scale (dyn. m)

$C_h$ = horizontal correlation
$C_v$ = vertical correlation
$C_f$ = flow correlation



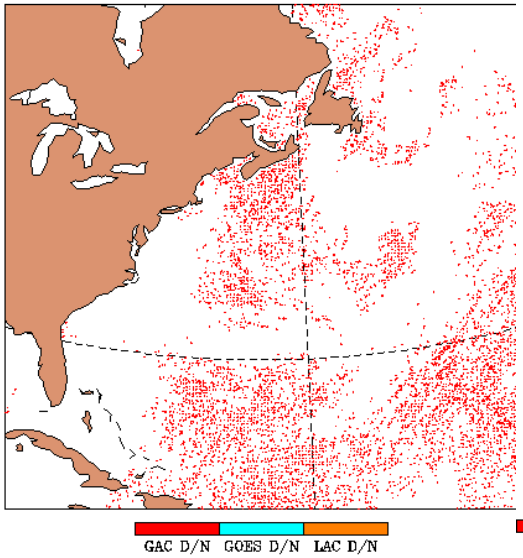

Geopotential Valid 5 August 2005 00Z
Contour Interval 0.1 dyn m

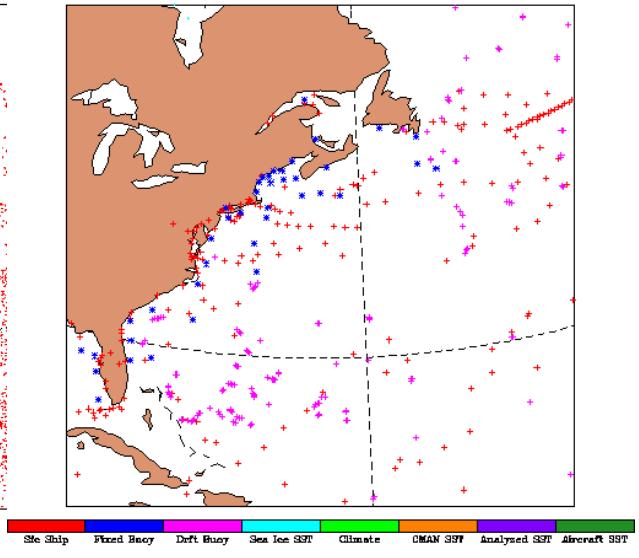


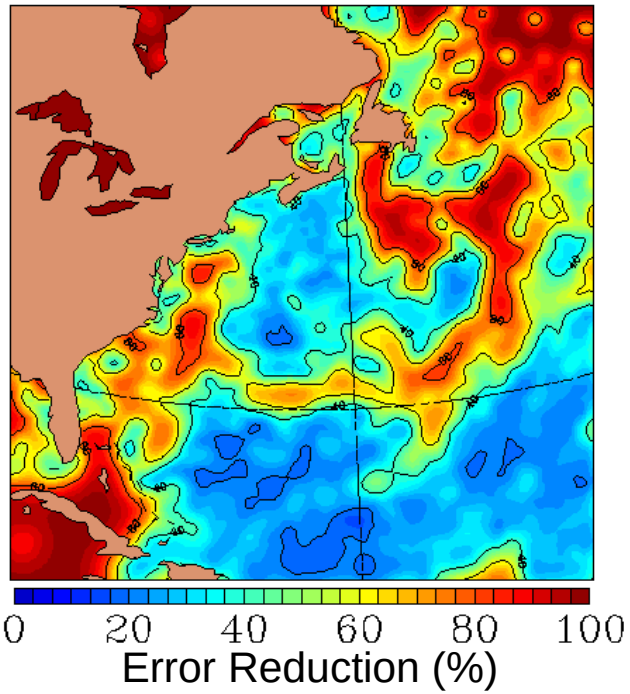

100 M Temperature Increments
6 August 00Z

# Analysis Error Reduction (%)

**Satellite SST** + **In Situ SST**




$$P_a = P_b - P_b H^T [H P_b H^T + R]^{-1} H P_b$$

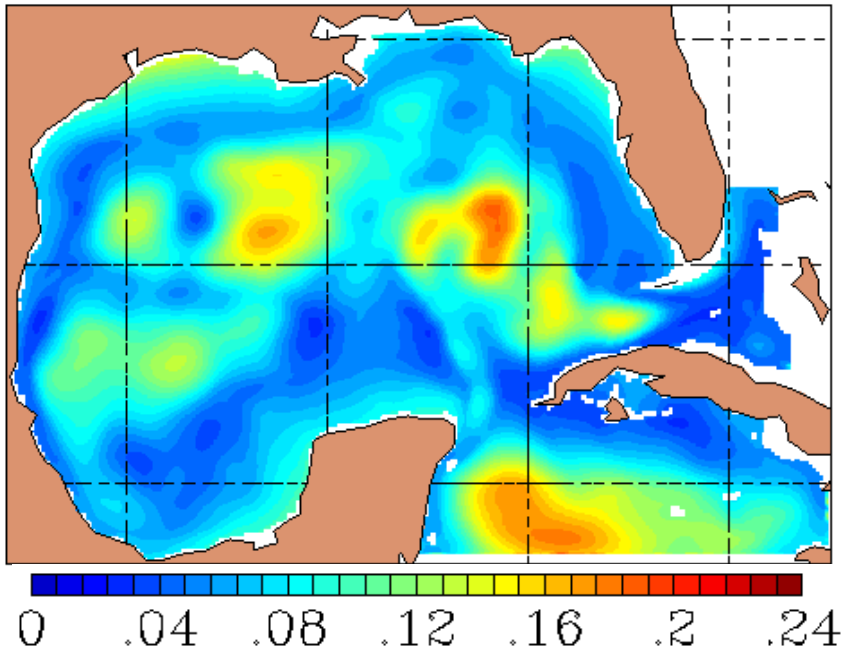
estimates the forecast error reduction due to the observing networks

$P_a$ - analysis error
$P_b$ - background error
$R$ - observation error
$H$ - measurement functional

***Will be used in ETKF to determine impact of glider data assimilation (adaptive sampling RTP)***

# Model Based Error Variances

- computed from differences of free running model states at analysis update cycle
- provides estimates of model error (variability) for all analysis variables (T,S,u,v,h)
- used by NCODA in time evolution of background error variances



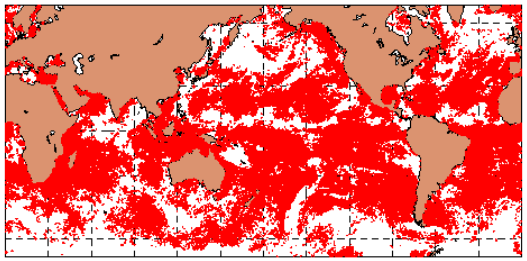

HYCOM SSH Model Climate Variability - 9 km grid Gulf Mexico

## NCODA Background Error Variances

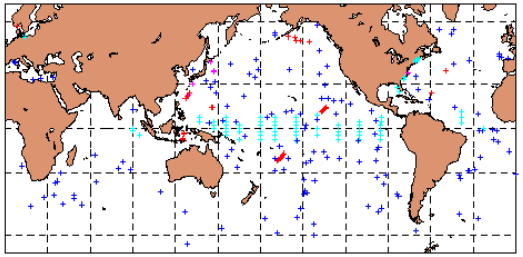
- vary by position, depth, analysis variable
- evolve with time, updated continuously using analyzed increment fields
- error growth parameterization in data void areas
  - – function of age of data on grid and temporal autocorrelations
  - – background errors asymptote at model (climate) variability in long term absence of observations

# New Analysis Variable: Age of Data on Grid (hrs)

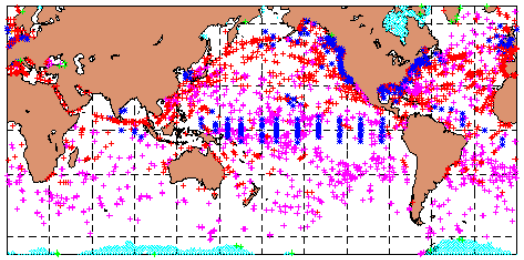
## number hours since grid point influenced by an observation



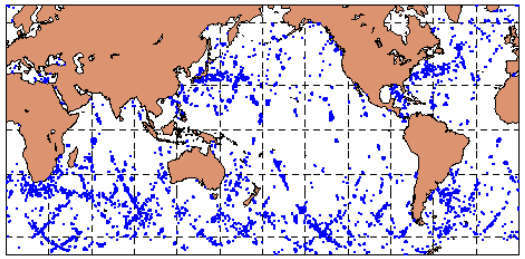
*Satellite SST*



*Profiles*

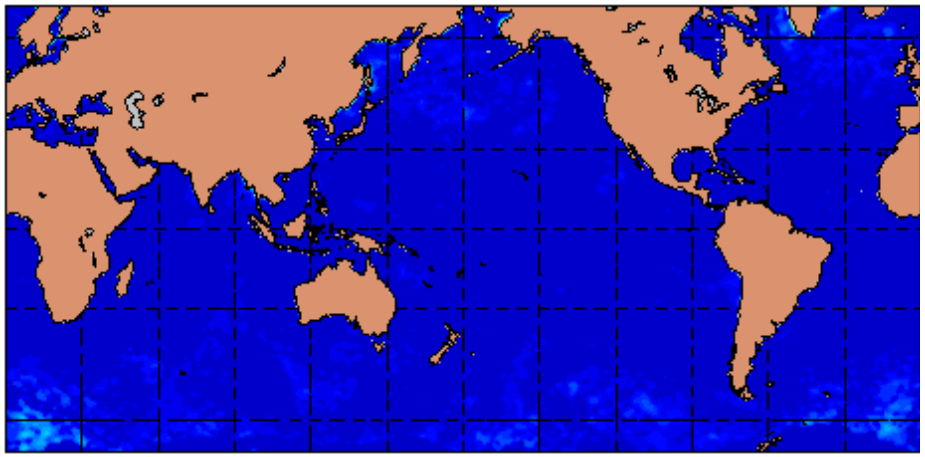


*In Situ SST*

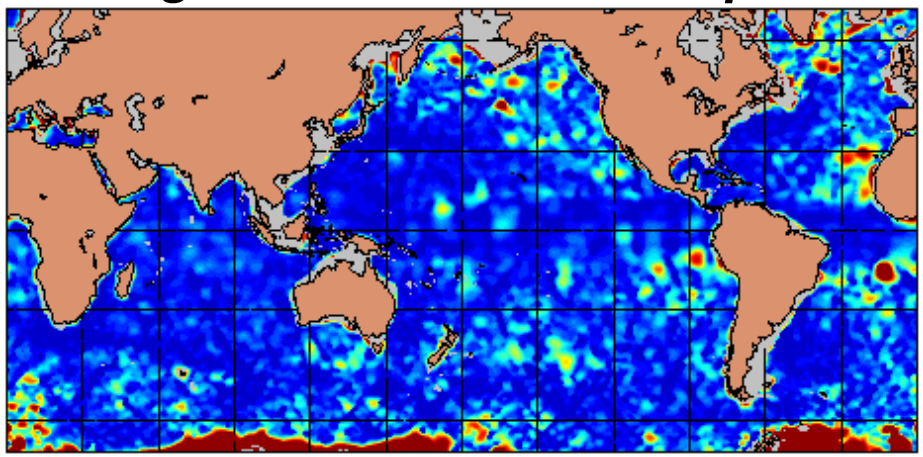


*MODAS Synthetics*

*Age of Data at Surface*

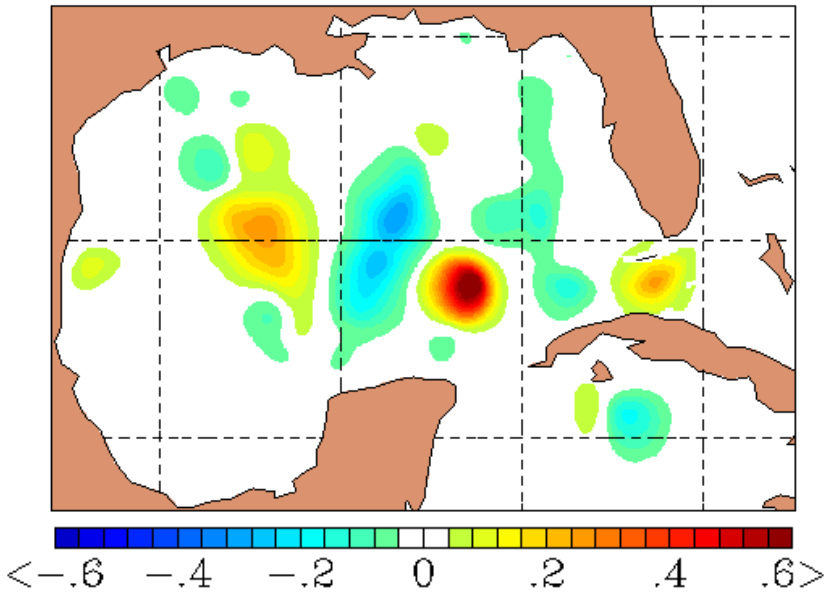


*Age of Data at 400 M Depth*

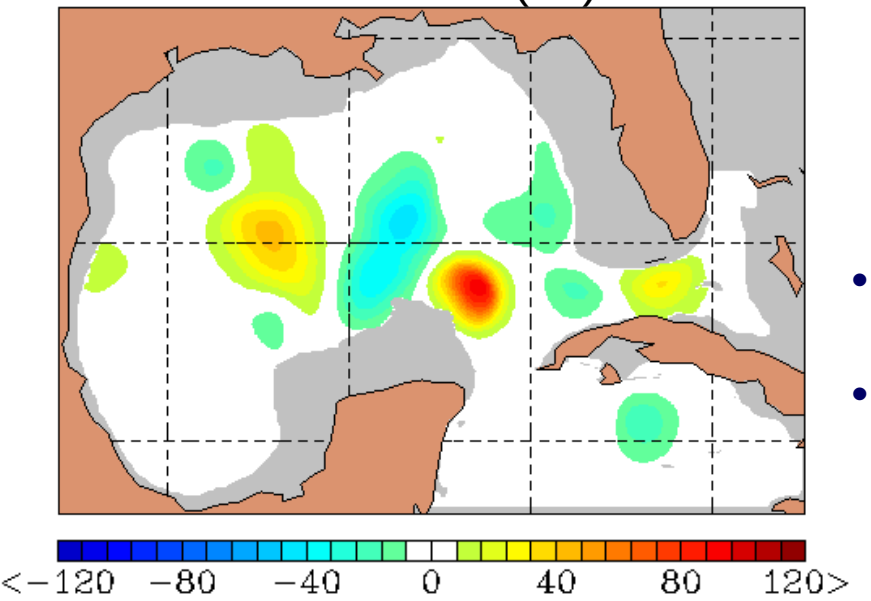



*2 June 2005 00Z*

SSH Increment (m)




Pressure Correction (db) at 100 M



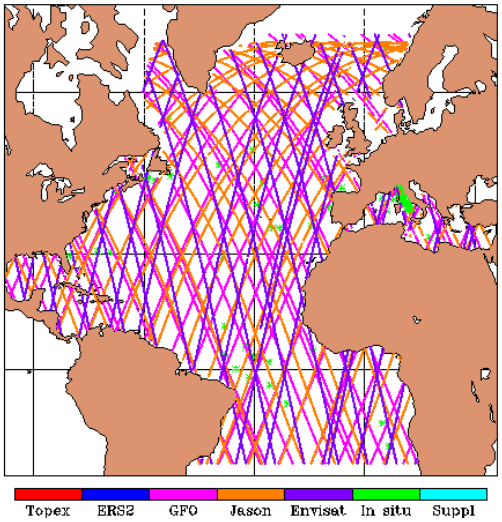

# New Analysis Variable: Pressure Correction (db)

- compute pressure innovation (**OmF**) of forecast density in observed density profile
- compute pressure innovation error from T,S,ρ errors scaled by observed potential density pressure gradient

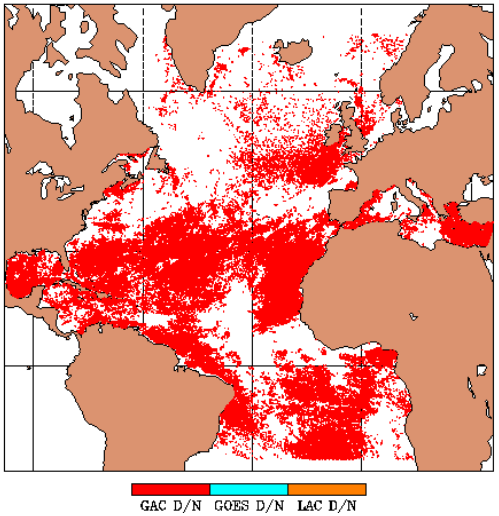
$$e_p = (e_\theta \bullet \partial\rho/\partial\theta + e_S \bullet \partial\rho/\partial S) \,/\, (\partial\rho/\partial p)$$

- assimilate pressure innovations using T/S covariances in **T,S,ϕ,u,v,p** analysis
- correct HYCOM forecast interface pressures when layers are at target density
  - positive: move the layer down, forecast density shallower than observed
  - negative: move the layer up, forecast density deeper than observed
- correct HYCOM forecast T,S,ρ when layers are not at target density
- apply constraints before initializing model
  - layer thickness is always positve
  - no bottom pressure change

# Data Restriction in Lateral Boundary Areas

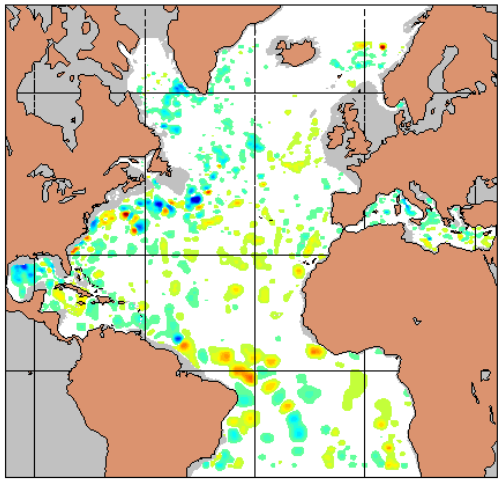



Altimeter

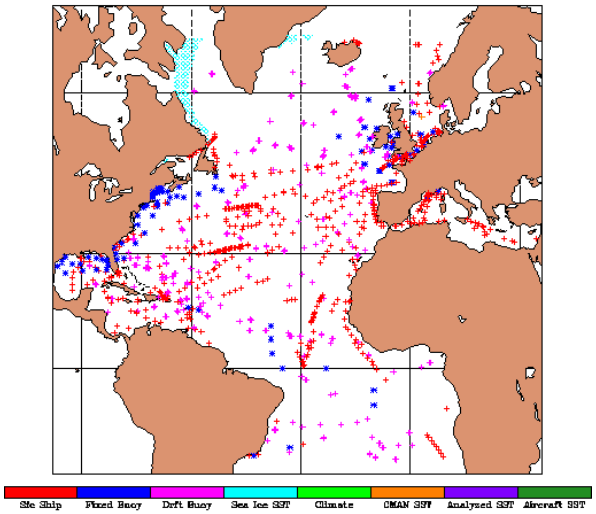



Satellite SST

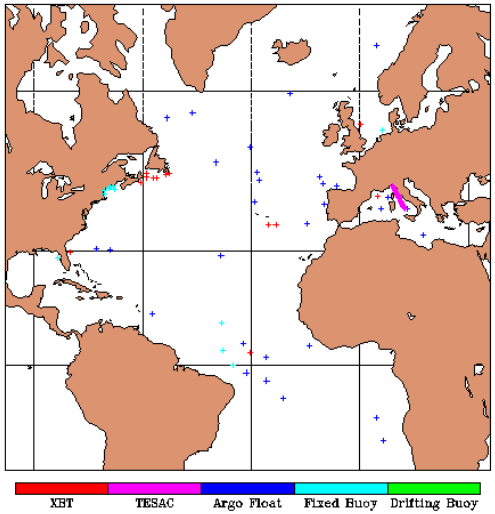
- model forecast not accurate in lateral boundary areas
- innovations (OmF) can be large in boundary areas
- analyzed increments from boundary areas can degrade forecast in active regions



Temperature Increments
200 M




In situ SST




Profiles

***END***